Status and Trends in the Lake Superior Fish Community, 2018[1]

Mark R. Vinson, Lori M. Evrard, Owen T. Gorman, Caroline Rosinski, Daniel L. Yule
U.S. Geological Survey Great Lakes Science Center Lake Superior Biological Station
2800 Lakeshore Drive East, Ashland, Wisconsin 54806 (mvinson@usgs.gov)

Abstract

In 2018, the Lake Superior fish community was sampled with daytime bottom trawls at 77 nearshore and 35 offshore stations distributed throughout the lake. Spring nearshore and summer offshore water temperatures in 2018 were cooler than the 1991-2018 average. In the nearshore zone, a total of 31,085 individual fish from 24 species or morphotypes were collected. The number of species collected at each station ranged from 0 to 15, with a mean of 4.5 and median of four. Nearshore mean biomass was 4.2 kg/ha which was below the long-term average of 8.7 kg/ha and the median nearshore biomass was 0.3 kg/ha, which was well below the long-term average median value of 1.9 kg/ha. Lake Whitefish, Rainbow Smelt, Cisco, Longnose Sucker, lean Lake Trout, siscowet Lake Trout, Burbot, and Bloater had the highest total collected biomass. In the offshore zone, a total of 8,042 individuals from 10 species or morphotypes were collected. The average and median observed species richness at each station was 2.8 and 3 species, respectively, and ranged from 0 to 5 species. Deepwater Sculpin, Kiyi, and siscowet Lake Trout made up 99% of the total number of individuals and biomass collected in offshore waters. Mean and median offshore biomass for all species in 2018 was 4.0 kg/ha and 3.3 kg/ha, respectively. This was less than the long-term mean of 6.5 kg/ha and median of 5.6 kg/ha. Nearshore average larval *Coregonus* densities in 2018 were less than any previous year; whereas offshore larval *Coregonus* densities were similar to that observed in previous years.

[1]Presented at: Great Lakes Fishery Commission, Lake Superior Committee Meeting, 27 March 2019. The data associated with this report are available at: U.S. Geological Survey, Great Lakes Science Center, 2019, Great Lakes Research Vessel Operations 1958-2018. (ver. 3.0, April 2019): U.S. Geological Survey data release, https://doi.org/10.5066/F75M63X0.
.

Introduction

The U.S. Geological Survey Lake Superior Biological Station conducts annual daytime bottom trawl surveys in nearshore (~15-80 m depths) and offshore (~100-300 m depths) waters of Lake Superior. These surveys provide data for assessment of long-term trends in species occurrence, relative abundance, and biomass for principally demersal fish species. Rather than absolute abundance and biomass estimates, these data have historically been considered population indices. Age and diet analyses are conducted for selected species. The nearshore survey has been conducted annually since 1978 in U.S. waters, and since 1989 in Canadian waters. The offshore survey has been conducted annually since 2011. We report population biomass estimates for common species and recruitment indices as the density of age-1 fish for selected commercial and recreational species (Rainbow Smelt, Cisco, Bloater, Lake Whitefish, and Lake Trout, scientific names are provided in Table 1) from nearshore surveys, and population biomass estimates from offshore surveys. Results presented for age-1 and older fish are based solely on bottom trawl sampling. Larval fish were collected using surface trawls. Fishing gear bias should be considered when interpreting the results of this survey, particularly for species with lower vulnerability to daytime bottom trawls, such as adult Cisco and adult Lake Trout. At each fish sampling station, a whole water column (up to 100 m) zooplankton sample is collected and an electronic water profiler is deployed that collects data on depth, water temperature, specific conductance, pH, dissolved oxygen, chlorophyll a, photosynthetic active radiation (PAR), and beam transmission. Herein we report on bottom and surface trawl fish collections and water temperatures.

Methods

Nearshore survey bottom trawling

Nearshore sites are located around the perimeter of the lake. In 2018, 77 of 79 long-term sites were sampled between 15 May and 15 June (Figure 1). The site at Gay, Michigan was not sampled due to weather and the site at Lester River, Minnesota was permanently dropped from the survey due to safety concerns of sampling too close to shore in inclement weather. At each location, a single bottom trawl tow was conducted with a 12-m Yankee bottom trawl with either a chain or 6-inch rubber roller foot rope. The roller foot rope was used at sites with steeper, rockier bottoms to reduce snagging. The median start and end depths for bottom trawl tows were 17 m (range 10-33 m) and 56 m (range 19-143 m), respectively. The median distance trawled was 1.6 km (range 0.4-4.0 km). The median trawl wingspread was 9.8 m (range 7.9-12.0 m). Fish collected in trawls were sorted by species, counted, and weighed in aggregate to the nearest gram. Total length was measured on a maximum of 50 individuals per species per trawl. Length data for these individuals were extrapolated to the entire catch when more than 50 individuals were collected. Relative density (fish/ha) and biomass (kg/ha) were estimated by dividing sample counts and aggregate weights by the area of the bottom swept by each trawl tow (ha). Biomass estimates are reported for all species combined and individually for Burbot, Cisco, Bloater, Rainbow Smelt, Lake Whitefish, Sculpin species (Slimy Sculpin, Spoonhead Sculpin, and Deepwater Sculpin), hatchery-, lean-, and siscowet Lake Trout, and for all other species combined. For Cisco, Bloater, Lake Whitefish, and Rainbow Smelt, age-1 year-class strength was estimated as the mean relative density of age-1 fish. Age-1 fish designations were based on total length; Cisco <140 mm, Bloater <130 mm, Lake Whitefish <160 mm, and Rainbow Smelt <100 mm. Young Lake Trout densities are presented for small, < 226 mm (ca. ≤ age-3) fish. These age-size cutoffs were based on past unpublished aging analyses and are approximate and are known to vary among years.

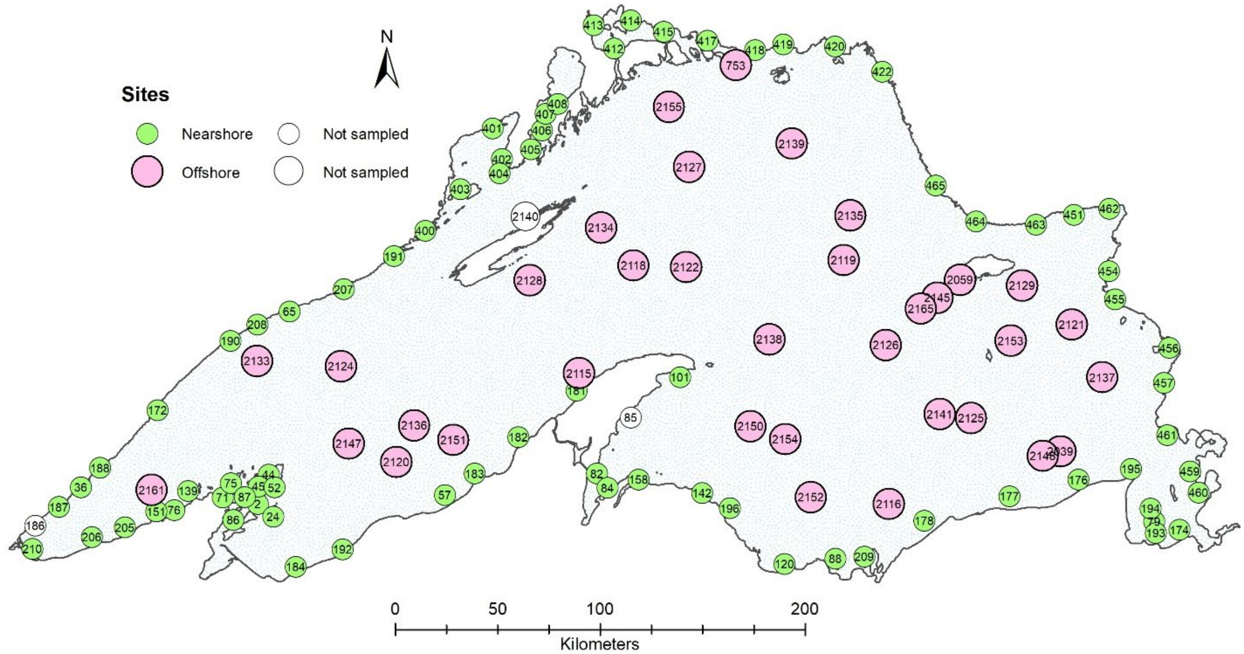

Figure 1. Location of 77 nearshore (green circles) and 35 offshore (pink circles) stations sampled May-July 2018. Two historically sampled nearshore and one offshore site were not sampled in 2018 and are shown as empty circles. Samples collected at each location included bottom trawls for demersal fish, surface trawls for larval fish, epilimnetic (30 m) and whole water column (100 m) zooplankton collections, and a water profile that electronically collected data on depth, temperature, specific conductance, pH, dissolved oxygen, chlorophyll a, photosynthetic active radiation, and beam transmission.

Offshore survey bottom trawling

Offshore sites were selected using a spatially-balanced, depth-weighted probabilistic sampling design that targets depths >85 m (Figure 1). Sample sites were selected in 2011 and the same sites have been sampled annually thereafter. In 2018, 35 locations were sampled during daylight hours from 11-25 July. The site on the west side of Isle Royale was not sampled to avoid collection of recently tagged siscowet Lake Trout near that location. A single bottom trawl tow was conducted at each site using a 12-m Yankee bottom trawl with a 6-inch rubber roller foot rope. All tows were made on-contour for 20 minutes. Station depths ranged from 89 to 314 m. The median trawl distance was 1.4 km (range 1.2-1.5 km). The median trawl wing spread was 10.8 m (range 9.4-12.0 m). Catches were processed similarly to that described for nearshore trawls. Biomass estimates are presented for all species and individually for Kiyi, Deepwater Sculpin, and siscowet Lake Trout.

Surface water trawling

To describe the abundance and spatial distribution of larval *Coregonus*, a paired 1 m^2 500 micron mesh neuston net was fished 0.5 m below the lake surface at each bottom trawl location. Neuston net trawls were made for 10 minutes and were typically done at the same time as bottom trawls. The median surface trawl distance was 0.7 km (range 0.6-0.8 km). A total of 120 trawls were made at 115 locations from 15 May to 25 July 2018. A site near Grand Marais, Minnesota was sampled on four dates. We are not able to identify larval *Coregonus* to species, so it is assumed these fish are a mix of Cisco, Bloater, and Kiyi. In addition to *Coregonus* species, a few larval Sculpin and Pacific Salmon were collected, but are not reported on.

Results

Nearshore survey

Nearshore water temperatures in 2018 were cooler than the long-term average (Figure 2a). Nearshore water temperatures in June averaged 4.3 °C (range = 2.7-15.6 °C) at the surface and 3.5 °C (range = 2.6-4.4 °C) at 50 m. The long-term average (1991-2018) water temperatures for these same locations and dates was 6.2 °C (average June range = 3.8-12.9 °C) at the surface and 4.0 °C (average June range = 3.1-5.5 °C) at 50 m.

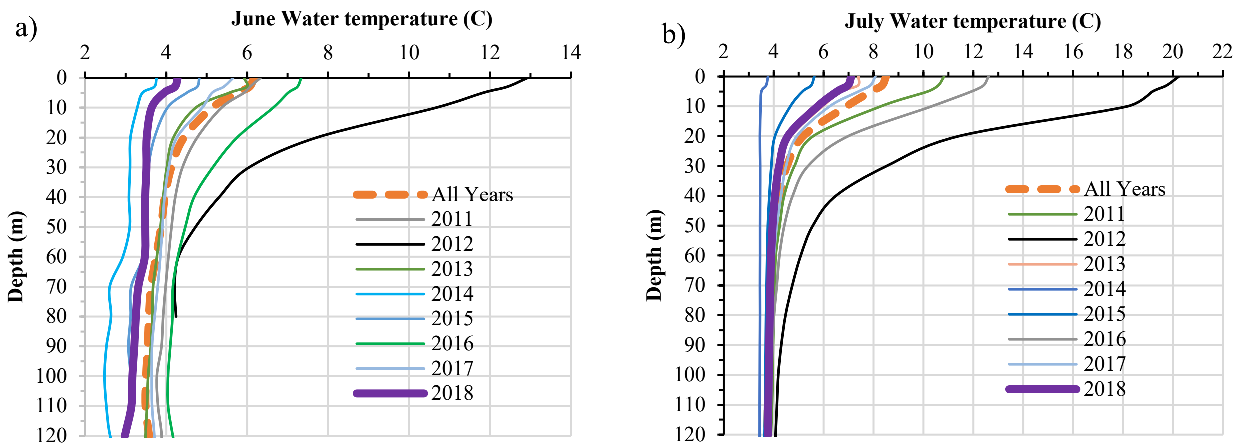

Figure 2. a) Average nearshore water temperature profiles collected in June. b) Average offshore water temperatures collected in July. All years is the average of temperatures collected from 1991-2018 for June and from 2011-2018 for July.

A total of 31,085 individual fish from 24 species or morphotypes were collected at nearshore locations (Table 1). The number of species collected at each station ranged from 0 to 15, with a mean of 4.5 and median of 4. Mean total nearshore fish biomass was 4.2 kg/ha, which was below the long-term average of 8.7 kg/ha (Table 2, Figure 3). Median total nearshore fish biomass was 0.3 kg/ha, which was well below the long-term average median value of 1.9 kg/ha (Figure 3). In relation to more recent estimates of fish biomass, the 2018 average nearshore biomass was greater than the previous 10 year average of 3.5 kg/ha and less than the 20 year average of 5.6 kg/ha (Figure 3).

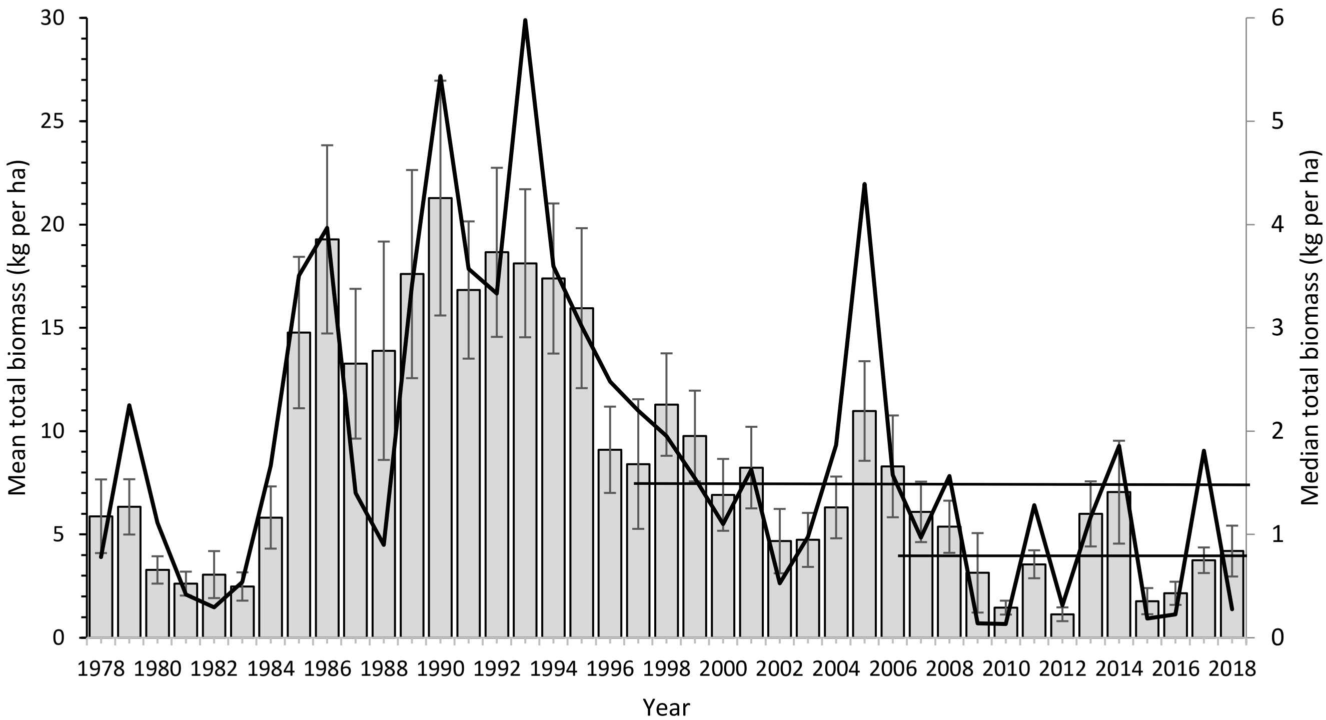

Figure 3. Annual mean ± SE (bars, left y-axis) and median (line, right y-axis) nearshore biomass estimates for all fish species collected in bottom trawls from 1978-2018. The horizontal lines are the previous 10 and 20 year average biomass estimates.

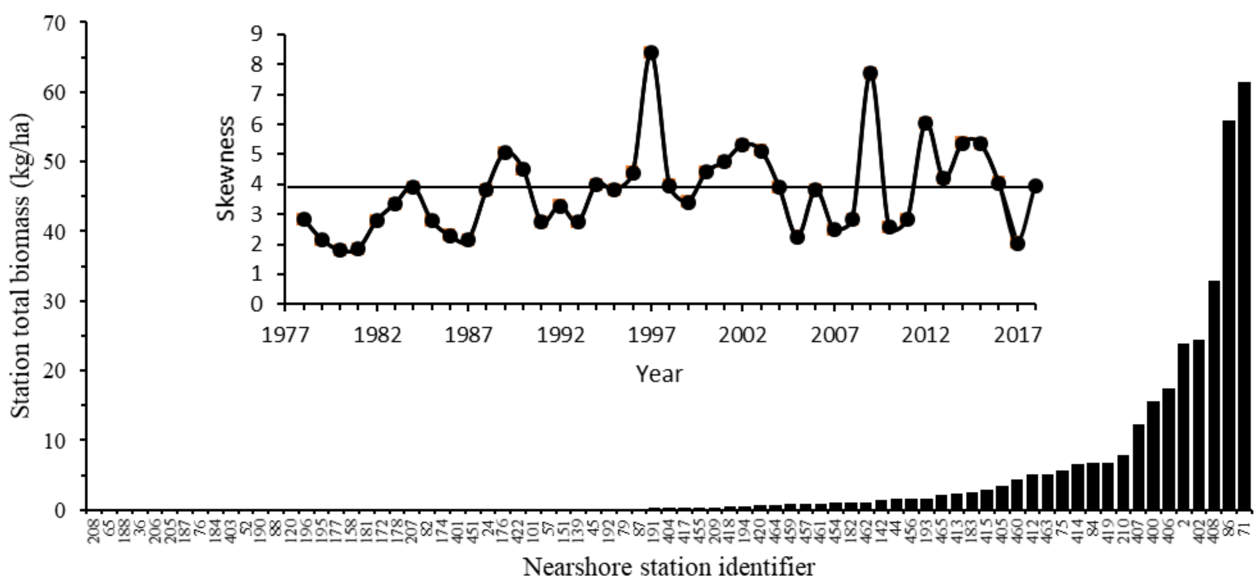

Figure 4. Estimated biomass at individual nearshore sampling stations in 2018. Station locations are shown in Figure 1. The inset plot shows the annual skewness in the distribution of individual station biomass estimates. Higher skewness values indicate greater differences in fish biomass among sampling locations. The horizontal line in the skewness plot is the long term average of 3.8.

Individual station *biomass* was non-normally distributed (Figure 4). The skewness of the distribution of individual station biomass estimates in 2018 was 3.9, which was similar to the long-term average skewness of 3.8 (Figure 4). Individual stations with the highest biomass were located in the Apostle Islands (2-Stockton Island, 86-Basswood Island, and 71-Raspberry Island) and along the Canadian shoreline near Thunder Bay (sites 406, 407, 408-Black Bay, 400-Cloud Bay, and 402-Sawyer Bay). In an oddity, no fish were collected at sites 76-Squaw Point, 205-Port Wing, and 206-Brule River. Collections at these sites are often among the highest of all nearshore sites sampled around the lake. Port Wing and Brule River were sampled on 23 May and Squaw Point was sampled on 24 May 2018. The cause of the lack of fish collected is unknown.

Cisco – Mean nearshore biomass of Cisco was 0.4 kg/ha in 2018. This was similar to that observed the prior eleven years, but below the long-term average of 2.3 kg/ha and median annual average of 1.1 kg/ha (Table 2). Density of age-1 Cisco was 0 fish/ha in 2018. A single age-1 Cisco was collected across the entire nearshore survey of 77 locations. The one age-1 Cisco was collected in the Apostle Islands. Over the 41-year history of the nearshore survey, densities of age-1 Cisco >1 fish/ha have been observed in roughly half of the years (24 years) and >10 fish/ha about 30% of the years (fourteen years). The last two annual Cisco recruitment indices that exceeded 10 fish/ha were the 2009 and 2014 year classes.

Bloater – Mean nearshore biomass for Bloater was 0.1 kg/ha in 2018. This was below the long-term average of 1.6 kg/ha and median annual average of 0.9 kg/ha (Table 2). Age-1 Bloater density was 0.1 fish/ha in 2018. This was below the long-term average of 8.3 fish/ha and median annual average of 0.8 fish/ha (Table 3).

Lake Whitefish – Mean nearshore biomass for Lake Whitefish was 1.5 kg/ha in 2018. This was less than the long-term average of 2.1 kg/ha and median annual average of 1.9 kg/ha (Table 2). Age-1 Lake Whitefish density was 1.1 fish/ha in 2018, which was below the long-term average of 7.0 fish/ha and less than the long-term median annual average of 5.5 fish/ha (Table 3).

Rainbow Smelt – Mean nearshore biomass for Rainbow Smelt was 1.2 kg/ha in 2018. This was similar to the long-term average of 1.1 kg/ha and median of 1.0 kg/ha. 2017 and 2018 were the first consecutive years that biomass levels of Rainbow Smelt approached 1 kg/ha since 2008 (Table 2). Between 1985 and 2002, Rainbow Smelt nearshore biomass consistently exceeded 1 kg/ha. Age-1 Rainbow Smelt density was 161 fish/ha in 2018, which was similar to the long long-term average of 157 fish/ ha and slightly more than the long-term median annual average of 148 fish/ha (Table 3).

Sculpin – Mean nearshore biomass for Sculpin was 0.02 kg/ha in 2018. This was below the long-term average of 0.06 kg/ha and median of 0.05 kg/ha, but was similar to that observed since 2011. Sculpin biomass has not exceeded 0.06 kg/ha since 1998 (Table 2).

Other forage fish species – The combined mean nearshore biomass for all other forage fish species was 0.6 kg/ha in 2018. This was similar to the long-term mean and median of 0.7 kg/ha (Table 2). Miscellaneous species included Ninespine Stickleback, Trout-perch, Kiyi, Shortjaw Cisco, Pygmy Whitefish, Round Whitefish, and Longnose Sucker. The highest biomass of these fishes were Long-nose Sucker (0.5 kg/ha), followed by Ninespine Stickleback (0.05 kg/ha), Trout-Perch (0.05 kg/ha), and Pygmy Whitefish (0.04 kg/ha).

Burbot – Mean nearshore biomass for Burbot was 0.1 kg/ha, which was equal to the long-term mean and median (Table 2).

Lake Trout – Three hatchery Lake Trout were collected during the 2018 nearshore survey. Hatchery Lake Trout biomass has been near zero since 2000, with the exception of 2005 (Figure 5). Lean Lake Trout biomass was 0.2 kg/ha. This was less than the long-term average and median of 0.3 kg/ha (Table 2). Siscowet Lake Trout nearshore biomass was 0.1 kg/ha, which was equal to the long-term average and median (Table 2). Densities of age-3 and younger lean and siscowet Lake Trout were 0.05 and 0.02 fish/ha in 2018, respectively (Table 3). Young lean Lake Trout densities were less than the long-term average of 0.3 fish/ha, while young siscowet Lake Trout densities were similar to the long-term mean and median average of 0.03 and 0.02 fish/ha, respectively (Table 3).

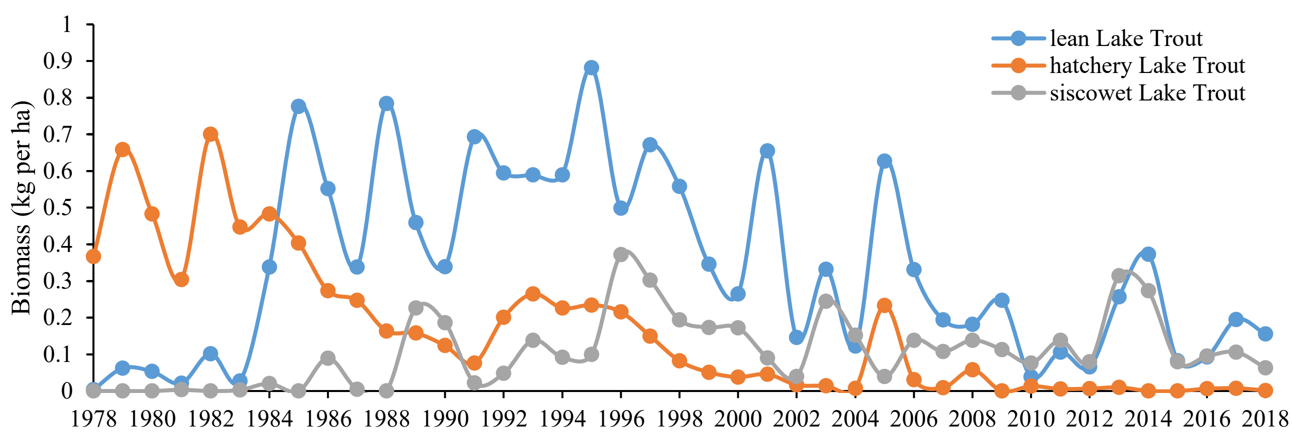

Figure 5. Mean annual nearshore biomass estimates for lean, hatchery, and siscowet Lake Trout estimated from bottom trawls in nearshore locations from 1978-2018.

Offshore survey

Offshore water temperatures were cooler than average (2011-2018) and warmer than observed in 2014 and 2015. Offshore water temperatures in July averaged 8.5 °C (range = 3.8-20.2 °C) at the surface and 3.8 °C (range = 3.4-4.2 °C) at 100 m (Figure 2b).

A total of 8,042 individuals from 10 species or morphotypes were collected at 35 offshore sites (Table 1). The average and median observed species richness at each station was 2.8 and 3 species, respectively, and ranged from 0 to 5 species. Deepwater Sculpin, Kiyi, and siscowet Lake Trout made up 99% of the total number of individuals and biomass collected in offshore waters (Table 1, Figure 6). Pygmy Whitefish and Slimy Sculpin were the most common other species collected (Table 1), but these species were generally limited to depths <100 m. Variation in biomass estimates across offshore sites was low. The standard error in biomass estimates across sites was 0.6 kg/ha for total biomass, 0.4 kg/ha for siscowet Lake Trout, 0.2 kg/ha for Kiyi, and 0.2 kg/ha for Deepwater Sculpin.

Mean and median offshore biomass for all species in 2018 was 4.0 kg/ha and 3.3 kg/ha, respectively. This was less than the long-term mean of 6.6 kg/ha and median of 5.6 kg/ha observed in 2011-2018 (Figure 7).

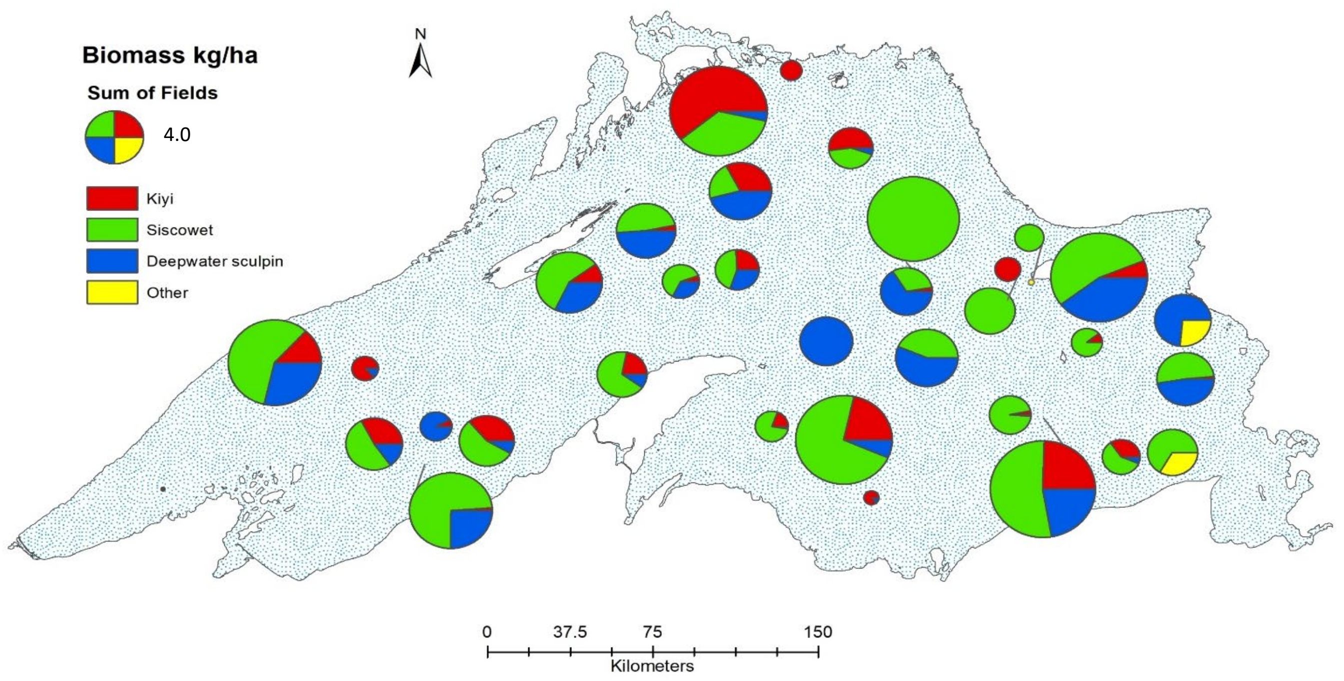

Figure 6. Offshore biomass estimates for Kiyi, siscowet Lake Trout, Deepwater Sculpin, and other species estimated from offshore bottom trawls in 2018. Pie diameter is proportional to the biomass collected at that site, which ranged from 0-13 kg/ha. The pie in the legend is scaled to the lakewide offshore average station biomass of 4.0 kg/ha with the size of the pies at individual stations scaled to that reference.

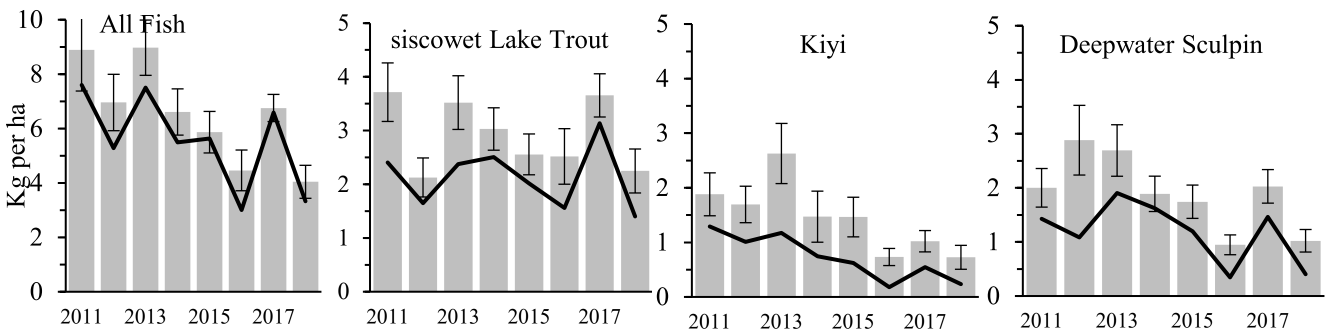

Figure 7. Annual mean ± SE (bars) and median (line) offshore biomass estimates for all species, siscowet Lake Trout, Kiyi and Deepwater Sculpin collected in bottom trawls from 2011-2018.

Siscowet Lake Trout – Mean offshore biomass for siscowet Lake Trout in 2018 was 2.2 kg/ha which was less than the long-term mean of 2.9 kg/ha.

Kiyi – Mean offshore biomass for Kiyi in 2018 was 0.7 kg/ha which was less than the long-term mean of 1.5 kg/ha (Figure 7). Kiyi biomass has had a decreasing trend since 2011. Kiyi age-1 density at offshore sites was 1.1 fish/ha and 0.01 fish/ha at nearshore sites in 2018. Similar to Cisco and Bloater, Kiyi year class strength in 2014 and 2015 were the highest recorded for the past decade, and were estimated at 16 age-1 kiyi/ha in both years at offshore sites.

Deepwater Sculpin – Mean offshore biomass for Deepwater Sculpin in 2018 was 1.0 kg/ha which was almost half of the long-term mean of 1.9 kg/ha (Figure 7).

Larval Coregonus collections

A total of 9,249 larval *Coregonus* individuals were collected from May-July 2018. The nearshore mean larval *Coregonus* density was 685 fish/ha (range 0-21,430 fish/ha) and the median density was 22 fish/ha. The average nearshore larval *Coregonus* density in 2018 was the lowest observed in the time series (Figure 8). Conversely, the average offshore larval *Coregonus* density in 2018 was similar to that observed in previous years and much higher than observed in 2017 (Figure 8), the lowest observed in the time series.

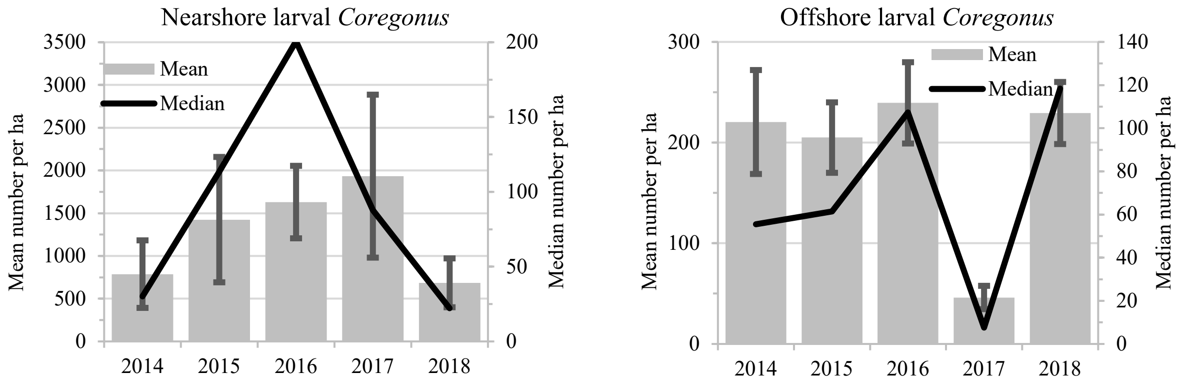

Figure 8. Annual mean ± SE (bars) and median (line) nearshore and offshore larval Coregonus abundance from 2014-2018.

Summary

Over the 41-year history of the Lake Superior nearshore survey, the relative magnitude of the estimated total biomass of demersal fish has been dependent on recruitment and survival of age-1+ Bloater, Cisco, and Lake Whitefish populations as well as survival of Rainbow Smelt to age-3 or older. The lack of significant recruitment (survival to age-1) in *Coregonus* species in recent years, particularly Cisco, has resulted in lower prey fish biomass estimates than were observed during 1985-2000. This is of concern to fishery managers. Factors underlying low recruitment in ciscoe stocks are not known but are being studied. Offshore demersal fish biomass estimates have exceeded nearshore demersal fish biomass estimates over the years the offshore survey has been conducted (2011-2018), except for this past year. In 2018, average nearshore and offshore demersal fish biomass estimates were similar at 4.2 and 4.0 kg/ha, respectively. Offshore demersal fish biomass has generally declined since 2011, with 2017 being an exception. Rate of decline has been higher for the two dominant prey fish, Deepwater Sculpin and Kiyi, and lower for the predator, siscowet Lake Trout.

After four years of collection, larval *Coregonus* population dynamics remain equivocal with respect to their ability to allow prediction of *Coregonus* survival to age-1. Larval *Coregonus* abundance estimates and growth rates were lower in 2014 than estimated in 2015-2017, yet survival of age-1 *Coregonus* was higher for the 2014-year class than any other year class. Nearshore larval *Coregonus* abundance estimates were highest in 2017, but in 2018 we found little evidence of survival to age-1. In 2018, nearshore mean larval *Coregonus* densities were low, whereas offshore estimates were similar to previous years.

The combination of our near- and offshore bottom trawl surveys provide a lakewide picture of the status and trends of the Lake Superior fish community susceptible to bottom trawls, particularly with respect to describing survival of *Coregonus* species to age-1 and lake trout morphotypes. Our plan is to continue these surveys into the future and adapt them as needed to address emerging issues.

Note: All GLSC sampling and handling of fish during research are carried out in accordance with guidelines for the care and use of fishes by the American Fisheries Society (http://fisheries.org/docs/wp/Guidelines-for-Use-of-Fishes.pdf).

Table 1. *Fish species and the number of individuals collected in nearshore and offshore bottom trawl surveys in Lake Superior in 2018. Sampling locations shown in Figure 1.*

Common name	Scientific name	Nearshore	Offshore
Rainbow smelt	*Osmerus mordax*	22361	3
Ninespine stickleback	*Pungitius pungitius*	4849	0
Trout-perch	*Percopsis omiscomaycus*	1413	0
Lake whitefish	*Coregonus clupeaformis*	668	0
Pygmy whitefish	*Prosopium coulterii*	524	31
Cisco	*Coregonus artedi*	364	0
Bloater	*Coregonus hoyi*	314	0
Slimy sculpin	*Cottus cognatus*	172	11
Deepwater sculpin	*Myoxocephalus thompsoni*	132	6970
Spoonhead sculpin	*Cottus ricei*	81	1
Lean lake trout	*Salvelinus namaycush*	52	2
Longnose sucker	*Catostomus catostomus*	49	0
Ruffe	*Gymnocephalus cernuus*	39	0
Siscowet lake trout	*Salvelinus namaycush siscowet*	27	175
Burbot	*Lota lota*	12	2
Kiyi	*Coregonus kiyi*	8	846
Yellow perch	*Perca flavescens*	6	0
Unidentified coregonid	*Coregonus*	4	0
Shortjaw cisco	*Coregonus zenithicus*	3	1
Hatchery lake trout	*Salvelinus namaycush*	3	0
Lake sturgeon	*Acipenser fulvescens*	1	0
Pink salmon	*Oncorhynchus gorbuscha*	1	0
Lake chub	*Hybopsis plumbea*	1	0
Johnny darter	*Etheostoma nigrum*	1	0

Table 2. *Mean annual Lake Superior nearshore bottom trawl biomass (kg/ha) estimates for common fishes. Sculpin includes Slimy, Spoonhead, and Deepwater sculpin. Mean and median total biomass includes all species. Miscellaneous species includes Ninespine Stickleback, Trout-Perch, Kiyi, Shortjaw Cisco, Pygmy Whitefish, Round Whitefish, and Longnose Sucker. No fish sites are the number of locations where no fish were collected.*

Year	Sites	No fish sites	Total species collected	Total biomass	Median biomass	Rainbow Smelt	Cisco	Lake Whitefish	Bloater	Hatchery Lake trout	lean Lake Trout	siscowet Lake Trout	Burbot	Sculpin	Misc. spp.
1978	43	0	17	5.9	0.8	4.1	0.0	0.7	0.1	0.4	0.0	0.0	0.2	0.14	0.3
1979	49	0	17	6.3	2.3	2.2	0.1	1.3	0.4	0.7	0.1	0.0	0.3	0.20	1.2
1980	48	0	16	3.3	1.1	0.9	0.3	0.6	0.3	0.5	0.1	0.0	0.2	0.19	0.3
1981	48	2	18	2.6	0.4	0.2	0.4	0.7	0.4	0.3	0.0	0.0	0.2	0.18	0.2
1982	32	0	18	3.1	0.3	0.2	0.3	0.8	0.4	0.7	0.1	0.0	0.1	0.03	0.3
1983	50	0	19	2.5	0.5	0.9	0.2	0.2	0.4	0.4	0.0	0.0	0.1	0.06	0.1
1984	53	0	21	5.8	1.7	0.8	0.6	1.3	1.7	0.5	0.3	0.0	0.2	0.06	0.2
1985	53	0	19	14.8	3.5	1.3	6.5	2.1	2.7	0.4	0.8	0.0	0.0	0.08	0.8
1986	53	2	18	19.3	4.0	2.8	8.7	2.6	3.8	0.3	0.6	0.1	0.2	0.07	0.2
1987	53	0	16	13.3	1.4	1.8	5.7	2.0	2.6	0.2	0.3	0.0	0.1	0.07	0.4
1988	53	0	19	13.9	0.9	1.2	3.1	2.4	6.0	0.2	0.8	0.0	0.1	0.04	0.2
1989	76	0	21	17.6	3.4	2.1	6.2	5.5	1.7	0.2	0.5	0.2	0.2	0.08	0.9
1990	81	0	22	21.3	5.4	2.0	10.1	2.4	4.8	0.1	0.3	0.2	0.1	0.08	1.2
1991	84	1	21	16.8	3.6	1.2	10.2	2.7	0.8	0.1	0.7	0.0	0.2	0.10	0.8
1992	85	0	24	18.7	3.3	1.0	3.4	3.7	8.4	0.2	0.6	0.0	0.2	0.07	1.1
1993	87	1	22	18.1	6.0	2.1	5.0	3.7	4.3	0.3	0.6	0.1	0.3	0.09	1.7
1994	87	0	23	17.4	3.6	1.9	7.2	5.4	0.4	0.2	0.6	0.1	0.1	0.08	1.3
1995	87	0	27	16.0	3.0	2.2	4.0	5.8	0.6	0.2	0.9	0.1	0.1	0.09	1.9
1996	87	0	26	9.1	2.5	1.3	1.0	1.6	3.1	0.2	0.5	0.4	0.2	0.11	0.7
1997	85	1	29	8.4	2.2	1.3	1.4	2.8	0.9	0.1	0.7	0.3	0.1	0.06	0.8
1998	87	0	22	11.3	2.0	1.5	1.1	2.3	4.4	0.1	0.6	0.2	0.1	0.07	1.1
1999	83	5	22	9.8	1.5	1.1	2.7	1.3	3.1	0.1	0.3	0.2	0.1	0.04	0.8
2000	85	4	24	6.9	1.1	0.8	2.4	1.6	0.9	0.0	0.3	0.2	0.0	0.04	0.6
2001	83	1	31	8.2	1.6	1.5	1.2	2.8	1.2	0.0	0.7	0.1	0.1	0.04	0.6
2002	84	2	25	4.7	0.5	0.2	1.5	1.7	0.6	0.0	0.1	0.0	0.1	0.02	0.4
2003	86	8	25	4.7	1.0	0.3	0.6	1.8	0.9	0.0	0.3	0.2	0.0	0.02	0.4
2004	75	1	24	6.3	1.9	0.3	1.8	1.9	1.1	0.0	0.1	0.2	0.2	0.03	0.6
2005	52	0	27	11.0	4.4	1.0	2.2	4.4	1.6	0.2	0.6	0.0	0.3	0.01	0.5
2006	55	2	23	8.3	1.6	0.9	2.2	1.7	1.8	0.0	0.3	0.1	0.1	0.02	1.0
2007	56	0	31	6.1	1.0	1.8	0.3	1.9	0.9	0.0	0.2	0.1	0.1	0.02	0.8
2008	59	3	22	5.4	1.6	0.9	0.4	2.4	0.2	0.1	0.2	0.1	0.3	0.02	0.8
2009	64	6	20	3.1	0.1	0.4	0.3	0.1	1.2	0.0	0.2	0.1	0.0	0.02	0.7
2010	76	11	24	1.5	0.1	0.2	0.3	0.3	0.2	0.0	0.0	0.1	0.0	0.05	0.2
2011	82	6	21	3.6	1.3	0.6	0.4	0.9	0.6	0.0	0.1	0.1	0.0	0.05	0.7
2012	72	16	25	1.1	0.3	0.2	0.0	0.2	0.4	0.0	0.1	0.1	0.0	0.03	0.3
2013	79	3	27	6.0	1.2	0.5	0.5	3.0	0.5	0.0	0.3	0.3	0.1	0.02	0.8
2014	73	3	28	7.0	1.9	0.4	0.4	4.3	0.5	0.0	0.4	0.3	0.1	0.02	0.7
2015	76	4	21	1.8	0.2	0.2	0.2	0.5	0.4	0.0	0.1	0.1	0.0	0.02	0.2
2016	76	6	23	2.2	0.2	0.4	0.2	0.5	0.4	0.0	0.1	0.1	0.0	0.02	0.3
2017	76	4	27	3.8	1.8	0.9	0.2	1.1	0.5	0.0	0.2	0.1	0.0	0.01	0.7
2018	77	10	24	4.2	0.3	1.2	0.4	1.5	0.1	0.0	0.2	0.1	0.1	0.02	0.6
Mean	69	2	22.6	8.7	1.9	1.1	2.3	2.1	1.6	0.2	0.3	0.1	0.1	0.06	0.7
Median	76	1	22.0	6.6	1.6	1.0	1.1	1.9	0.9	0.1	0.3	0.1	0.1	0.05	0.7

Table 3. Mean a*nnual Lake Superior nearshore bottom trawl age-1 density (number/ha) estimates for Cisco, Bloater, Lake Whitefish, and Rainbow Smelt and for small lean and siscowet Lake Trout. Age-1 fish were defined by species-specific lengths: Cisco <140 mm, Bloater <130 mm, Lake Whitefish <160 mm, and Rainbow Smelt <100 mm. Lean and siscowet Lake Trout data are for fish <226 mm, ca. ~< age 3.*

Year	Year Class	Sites	Rainbow Smelt	Cisco	Bloater	Lake Whitefish	Kiyi	lean Lake Trout	siscowet Lake Trout
1978	1977	43	95.8	0.0	0.8	2.6	0.00	0.11	0.00
1979	1978	49	234.1	6.3	30.1	3.9	0.00	0.17	0.00
1980	1979	48	96.8	0.1	1.6	2.0	0.00	0.12	0.00
1981	1980	48	106.3	13.5	6.8	16.4	0.00	0.28	0.03
1982	1981	32	63.8	0.2	0.7	4.2	0.00	0.22	0.00
1983	1982	50	103.6	0.0	0.8	0.5	0.00	0.20	0.00
1984	1983	53	224.4	21.8	4.7	8.0	0.00	0.59	0.00
1985	1984	53	149.5	748.0	44.0	2.5	0.00	0.65	0.00
1986	1985	53	150.4	68.9	30.5	3.4	0.00	0.43	0.06
1987	1986	53	275.6	5.4	4.2	11.9	0.00	0.36	0.02
1988	1987	53	155.3	0.5	6.9	6.1	0.01	0.26	0.00
1989	1988	76	274.8	226.8	37.7	36.1	0.00	0.13	0.07
1990	1989	81	272.0	425.6	57.3	8.8	0.01	0.22	0.02
1991	1990	84	162.0	236.9	11.4	17.5	0.00	0.33	0.01
1992	1991	85	176.9	9.1	10.7	11.8	0.06	0.40	0.02
1993	1992	87	155.2	3.3	0.2	7.7	0.02	0.42	0.10
1994	1993	87	198.6	0.8	0.1	5.0	0.02	0.57	0.01
1995	1994	87	401.8	1.5	0.0	13.5	0.02	0.86	0.02
1996	1995	87	168.2	1.0	0.1	6.3	0.01	1.13	0.10
1997	1996	85	253.0	11.1	0.2	8.8	0.00	0.39	0.04
1998	1997	87	145.0	1.2	0.1	7.7	0.02	0.60	0.02
1999	1998	83	216.2	90.8	0.4	9.2	0.05	0.16	0.05
2000	1999	85	58.4	3.8	0.5	0.8	0.26	0.18	0.01
2001	2000	83	256.3	0.8	0.1	2.4	0.00	0.26	0.02
2002	2001	84	56.8	0.5	0.1	13.7	0.00	0.12	0.03
2003	2002	86	77.8	33.2	0.6	7.7	0.01	0.09	0.01
2004	2003	75	70.3	175.3	27.2	6.4	0.11	0.12	0.01
2005	2004	52	110.4	8.2	12.1	3.0	0.12	0.30	0.03
2006	2005	55	249.6	18.6	13.6	5.5	0.13	0.24	0.10
2007	2006	56	360.9	0.4	0.3	19.7	0.01	0.05	0.03
2008	2007	59	280.7	0.2	0.3	0.6	0.00	0.10	0.04
2009	2008	64	71.6	0.3	0.6	3.0	0.00	0.04	0.03
2010	2009	76	45.4	14.0	2.5	6.6	0.01	0.02	0.02
2011	2010	82	74.0	0.3	0.8	4.0	0.01	0.22	0.01
2012	2011	72	11.1	0.0	0.1	1.9	0.00	0.20	0.03
2013	2012	79	142.9	0.2	0.2	5.5	0.00	0.18	0.03
2014	2013	73	68.5	0.0	0.1	2.3	0.00	0.00	0.03
2015	2014	76	30.7	14.3	8.6	1.0	0.09	0.07	0.03
2016	2015	76	83.0	5.0	9.8	1.6	0.12	0.19	0.04
2017	2016	76	146.9	1.4	5.8	1.4	0.17	0.42	0.01
2018	2017	77	161.4	0.0	0.1	1.1	0.01	0.05	0.02
Mean		69	156.9	53.7	8.3	7.0	0.03	0.29	0.03
Median		76	148.2	3.6	0.8	5.5	0.01	0.22	0.02